1.5 Mining Research Plan (Strategic Goals)

Introduction

The Mining Research Plan was developed to focus the research and prevention activities on the areas of greatest need, as articulated by our customers and stakeholders and illustrated by the surveillance data. In a time of diminishing resources and increasing customer expectations, it was seen as a prerequisite to improved resource allocation. The Plan represents a vehicle to communicate more clearly, both internally and externally, what it is we are doing, why we are doing it, and how we will know when we have done it.

Strategic Research Goals

A melding of the priorities, as established from the surveillance data, stakeholder/customer requests, and loss control, is performed to establish a set of strategic research priorities. While the top-level goal is to improve mining safety and health, this will only be achieved by eliminating the fatalities, injuries, and illnesses that were summarized previously. Accordingly, the first six strategic goals are defined. These are:

Strategic Goal 1: Reduce respiratory diseases in miners by reducing health hazards in the workplace associated with coal worker pneumoconiosis, silicosis, and diesel emissions.

Strategic Goal 2: Reduce noise-induced hearing loss (NIHL) in the mining industry.

Strategic Goal 3: Reduce repetitive/cumulative musculoskeletal injuries in mine workers.

Strategic Goal 4: Reduce traumatic injuries in the mining workplace.

Strategic Goal 5: Reduce the risk of mine disasters (fires, explosions, and inundations); and minimize the risk to, and enhance the safety and effectiveness of, emergency responders.

Strategic Goal 6: Reduce ground failure fatalities and injuries in the mining industry.

The above goals and their performance measures were established in the context of a 10 year planning horizon.

The seventh goal is aimed at preventing potentially adverse health or safety outcomes that may result from changes in the industry.

Strategic Goal 7: Determine the impact of changing mining conditions, new and emerging technologies, training, and the changing patterns of work on worker health and safety.

Researchers have identified many of the barriers, knowledge gaps, or technology gaps that must be addressed to affect a desired change at the strategic goal level. These are articulated as intermediate goals, which are presented for each strategic goal. The major steps that must be taken to achieve each intermediate goal are captured as annual goals. An average timeframe for achievement of an intermediate goal is 5 years. Annual goals, however, are articulated for only 2 or 3 years at a time, to reflect both the uncertainty of the research process and variations in funding levels. Annual goals are not included in the Plan, as these are developed and used on a year-to-year basis by the researchers and first-level research supervisors.

It should also be noted that the set of intermediate goals defined in this Plan, for each strategic goal, represents the areas that NIOSH is committed to solving. It is likely that other intermediate goals will need to be achieved before it will be possible to fully achieve the strategic goal. The intermediate goals identified in this Plan were selected because they are on the critical path to achieve the strategic goal, and they are potentially achievable with the staff, facilities, and funds that are expected to be available. This Plan does not incorporate the essential research that will be conducted at universities or other agencies here and abroad.

The performance measures associated with the strategic goal reflect our ability to effect change with our resources. In most cases there are additional intermediate goals that are not being addressed by NIOSH, which must be achieved before the strategic goal can be fully realized. The performance measures are meant to provide meaningful targets to researchers, as well as to measure accomplishment. Existing evidence and expert judgment have guided our formulation of performance measures. Mine- and industry-level data, surveillance and intervention effectiveness data, customer and stakeholder inputs, and loss control assessments suggest that the measures are both reasonable and ambitious. On this basis, our measures represent approximate targets rather than precise projections of anticipated outcomes.

Strategic Goal 1: Reduce respiratory diseases in miners by reducing health hazards in the workplace associated with coal worker pneumoconiosis, silicosis, and diesel emissions

The primary focus of this goal is on reducing the respiratory diseases that result from exposure to coal dust, silica dust, and diesel particulate matter (DPM). Coal dust leads to coal worker pneumoconiosis (CWP), silica dust leads to silicosis, and DPM may be carcinogenic or cause other adverse health effects. All three are considered significant health hazards in mining. The ultimate goal is the elimination of new cases of CWP, silicosis, and the adverse health impacts of DPM. However, given the latency of the diseases in question, a period of 25-35 years will be required to achieve this goal. However, over a 10-year timeframe, significant progress toward this goal can be achieved by reducing worker exposure, and this can be effectively measured by looking at the reductions in dust, silica, and DPM concentrations to which workers are exposed.

The three major barriers to accomplishing this goal are the lack of a clear understanding of how miners receive their exposures to these health hazards, the current inability to obtain real-time exposure data, and the need for ever-improving mine-worthy engineering controls to protect miners from constantly increasing hazard concentrations.

Current sampling technology for dust, silica, and DPM provides an end of shift exposure measure and does not tell anything about how the worker received his exposure. By understanding the relationship between a worker's actions during a working shift and the sources of dust and DPM to which the worker is exposed, intelligent decisions can be made as to where administrative controls could be employed to reduce exposures and where engineering controls are needed. Real-time dust and DPM monitors would provide this much-needed information.

For years, mining stakeholders (both industry and labor) have expressed the need for real-time, person-wearable monitors for dust and DPM. Since 1980, the United Mine Workers of America have been asking for a real-time dust monitor to empower miners to do something about exposures before they occur. The Secretary of Labor's Advisory Committee on the Elimination of Pneumoconiosis Among Coal Mine Workers (1996) called for the development of continuous respirable dust monitors to help protect workers' health. Such a device would not only make it possible to observe what worker activities result in high exposures, but would also allow for actions to be taken to prevent overexposures before they occur. Presently, several days pass between the sampling of dust and the availability of results, making it impossible to take any timely corrective actions.

As mining production rates increase, there are accompanying increases in the production of coal dust, silica, and DPM. Thus, there is a continual need to develop and improve engineering control technologies to reduce the associated increased exposures. Since the introduction of longwall mining systems in the United States around 1970, longwall shearer advance rates have increased from 3 to 4 ft per minute to over 75 ft per minute, and average longwall shift production has increased from under 500 tons per shift to well over 5,000 tons per shift. This change has resulted in significant increases in dust production, making earlier control technologies inadequate. Increased usage of diesel equipment in mines has resulted in corresponding increases in DPM levels in mines, requiring additional control technologies. Furthermore, new or more rigid enforcement standards have made better control technologies a necessity.

Worker medical monitoring and surveillance findings can serve as a basis for prevention when primary methods (e.g., dust control and personal protection) fail. Failures of primary prevention occur because of imperfect standards (e.g., permissible exposure limits); suboptimal enforcement of, and compliance with standards; unrecognized hazards; and other factors that put workers at increased risk. For decades, worker medical monitoring using chest x-rays has been the method of choice for detecting the pneumoconiosis. Underground coal miners in the United States have been able to avail themselves of the benefits of radiographic monitoring for over 30 years through the NIOSH Coal Workers' X-ray Surveillance Program. Worker medical (as opposed to hazard/environmental) monitoring has the primary aim of preventing development of physical impairment and disability due to disease among individual workers found to exhibit early signs of disease. Case and case-cluster detection can also point to the need for adoption of more effective primary prevention approaches to protect other, as yet unaffected, workers from developing disease.

Performance Measure: This goal will be achieved by reducing the respirable coal dust overexposures of operators of longwall and continuous mining machines, roof bolters, and surface drills by 50% and the overall silica exposure of crusher operators and stone cutters by 50% within 10 years. The goal will also be achieved by reducing coal miner exposure to DPM by 80% and metal and nonmetal miner DPM overexposure rates by 50% within 10 years.

Intermediate Goal 1.1: Develop real-time, person-wearable monitoring technology for respirable coal dust. The availability of such a monitor(s) will empower both miners and management to take corrective action before overexposures can occur. Current reliable, real-time dust monitoring technology is large and not designed to withstand the rigors of the mine environment. This technology must be miniaturized and hardened before it can be successfully employed underground. This entails reducing the current 150-lb environmental sampler down to a person-wearable, 2-lb unit. In addition, other scientific and engineering barriers must be overcome to realize a practical mine-worthy device. These include determining a sampling intake location that is representative of the miner's breathing zone, designing the instrument to correctly size and measure the respirable portion of mine coal dust, and insuring that the instrument is capable of microgram accuracy.

Performance Measure: This goal will be achieved if a real-time person-wearable dust monitor is commercially available and in use by 2009.

Intermediate Goal 1.2: Reduce exposure to coal dust for longwall miners. Historic and current compliance sampling results show that workers on longwall faces are the most frequently overexposed workers in underground coal mining. More effective control technologies are needed, especially since continuing gains in productivity are resulting in corresponding increases in respirable dust.

Performance Measure: This goal will be achieved if the frequency of overexposure is reduced by 50% over the next 6 years (baseline is 2003).

Intermediate Goal 1.3: Reduce coal miner exposure to silica and coal dust. Recent compliance sampling results show that 23% of continuous miner operators, 25% of roof bolter operators, and 31% of surface drill operators are overexposed to silica. Research will be directed at establishing how dust is generated and becomes airborne in these mining operations and then at developing control technologies to reduce these airborne dust concentrations. Reducing the exposure of these specific occupations, as well as other high exposure occupations, will have the additional benefit of reducing the exposure of other workers in the surrounding work area.

Performance Measure: This goal will be achieved if improved control technologies reduce the frequency of overexposure of continuous miner operators, roof bolter operators, and surface drill operators by 50% within 5 years (baseline is 2003).

Intermediate Goal 1.4: Reduce the silica dust exposure of workers in metal and nonmetal mines and mills. Personal sampling results indicate that many high-risk occupations, such as crusher operators, heavy equipment operators, and stone cutters in metal and nonmetal operations are experiencing overexposure to silica dust levels. For example, 35% of silica compliance samples for dimension stone cutters exceed the allowable level. NIOSH is developing improved control technologies to reduce the silica dust exposure in these, and other high risk occupations.

Performance Measure: This goal will be achieved if improved control technologies reduce silica exposures by 50% for crusher operators in mines and mills, workers in enclosed equipment cabs, and stone cutters in dimension stone plants within 4 years (baseline is 2003).

Intermediate Goal 1.5: Reduce miner exposure to diesel emissions in underground mines. Recent surveys have shown that individuals working in underground mines where diesel-powered equipment is used are exposed to DPM concentrations that exceed those of any other occupation. Technology gaps exist in the design, selection, and application of emissions control technologies as well as in laboratory and field measurement methods. The objective is to reduce miner exposure to DPM by facilitating the application of current and evolving diesel emission control technologies into underground mines.

Performance Measure: This goal will be achieved if (1) underground coal miners' exposure to DPM is reduced by 60% within 6 years and (2) the frequency of overexposure of metal and nonmetal miners to DPM is reduced by 40% (assuming the current 400-µg/m3 standard) (baseline is 2003).

Intermediate Goal 1.6: Reduce exposure to dust, silica, and diesel emissions in large-opening mines through the development of improved ventilation science. Ventilation can be a highly effective tool for diluting and removing respiratory hazards in mines. Large-opening mines are difficult to effectively ventilate. This is due to the size of the openings and the large volumes of airflow required for removing and diluting pollutants. NIOSH is developing improved ventilation designs for these large-opening mines.

Performance Measure: This goal will be achieved if 20% of large-opening mines incorporate these improved ventilation designs within 5 years.

Strategic Goal 2: Reduce noise-induced hearing loss (NIHL) in the mining industry

NIHL is the most common occupational illness in the United States. The use of heavy equipment, the inherently noisy aspect of ore winning processes, and the confined work environment are some of the factors that contribute to high levels of noise exposure to workers in the mining industry. Every day 80% of the Nation's miners go to work in an environment where the time-weighted average (TWA) exceeds 85 dB(A). Moreover, 25% of the miners are exposed to a TWA noise level that exceeds 90 dB(A) - the permissible exposure limit (PEL). Furthermore, a NIOSH analysis of a large sample of audiograms revealed that by age 50, approximately 90% of coal miners and 49% of metal/nonmetal miners have a material hearing impairment. By contrast, only 10% of the nonoccupational noise-exposed population has a hearing impairment at age 50. Simply stated, the majority of miners have a 25-dB or greater hearing loss by the time they retire. Although NIHL is the most common occupational disease in this country, the problem is especially acute among workers in the mining industry.

There are several barriers to reducing NIHL. These include gaps in knowledge of noise dose/source relationships, the unavailability of effective noise controls, and needs for worker education and worker empowerment. A related issue is the difficulty of communication in noisy workplaces by both hearing-impaired and normally hearing workers.

Noise dose/source relationships. - The mining industry has not dedicated the resources to determine where workers receive their noise exposures. Knowledge of the noise source/exposure relationship will allow for effective selection and implementation of noise controls, thus reducing NIHL within the mining population.

Availability of effective noise controls. - In many cases, attempts at reducing sound levels with noise controls are unsuccessful because of misapplication of technologies and/or treating a noise source that is insignificant in terms of a worker's exposure. In other cases, noise controls have not been developed because of the lack of understanding of the mechanisms of noise generation or the inability to develop controls that have suitable durability in the mining environment.

Worker education. - Workers typically receive inadequate education about what they can do to conserve their hearing. Common problems include training that is sporadic and uninteresting, little feedback on whether the training actually increased their knowledge or skills, and an overemphasis on hearing protection at the expense of the many other strategies workers can utilize to reduce their noise exposures.

Worker empowerment. - Workers report that they are rarely included or consulted in hearing conservation efforts. However, their involvement is crucial for the effective deployment of most exposure reduction strategies. Workers need to have better information about the noise hazards in their workplaces and how much actual exposure they are receiving from these sources. They also need to be empowered with techniques to reduce their exposure by playing a greater part in the overall hearing conservation effort.

Communication issues. - In mines and other noisy settings, workers report a significant problem with hearing warning signals, speech, and other sounds that are critical to working safely and efficiently. This problem is exacerbated by the masking nature of background noise, the high prevalence of hearing impairment, and the over reliance on simple hearing protection to reduce exposures.

Performance Measure: The shorter-term goal of this research will be achieved if the frequency of noise overexposure of miners is reduced by 25% in 5 years and 50% in 10 years. However, NIHL usually occurs gradually over a career. The ultimate long-term measure of success is the elimination of new cases of NIHL. The overall success of our hearing loss prevention research will only be seen in 20-30 years.

Intermediate Goal 2.1: Develop and maintain a noise source/mine worker exposure database for prioritizing noise control technology.

This database will identify and quantify the sources of noise in various mining environments and correlate these to workers' noise exposures. The source/exposure relationship will be developed from data collected during mine-site surveys of underground and surface coal mines, coal preparation plants, and underground and surface metal and nonmetal mining sites. The database of noise source/worker exposures will be used by NIOSH and key stakeholders to develop and prioritize control technology efforts.

Performance Measure: This goal will be achieved through development of a database of noise source/exposure relationships and equipment noise in all mining commodities and its use by the mining industry and the Mine Safety and Health Administration (MSHA) by 2008.

Intermediate Goal 2.2: Develop engineering noise control technologies applicable to surface and underground mining equipment.

Generalized procedures for the application and evaluation of suitable noise control technologies in mining environments will be developed for all mining commodities. The information will provide the industry with guidelines for applying and evaluating noise controls that will enable mine operators to reduce worker noise exposure. In addition, new or improved engineering noise controls will be developed, evaluated, and field tested to reduce sound levels produced by mining machinery used in the mining environment, thereby reducing noise exposure to mine workers.

Performance Measure: The goal for existing noise controls will be achieved by disseminating comprehensive procedures for the evaluation and application of suitable noise controls in underground and surface metal, nonmetal, and coal mines within 3, 4, and 5 years, respectively. The goal for noise control development will be achieved if the industry implements effective new noise controls that reduce the noise overexposures of miners by 25% (versus the baseline values) by 2009.

Intermediate Goal 2.3: Empower workers to acquire and pursue more effective hearing conservation actions.

Workers continue to be exposed to hazardous noise levels even in situations where noise controls and hearing protectors are available. The workers themselves need to be empowered with the motivation, knowledge, and skills to take more effective preventive actions. NIOSH will develop and test a range of more effective training, communication, and feedback techniques that will give workers the tools they need for conserving their own hearing.

Performance Measure: This goal will be achieved through measures of dissemination and usage of communication, training, and empowerment tools by 2006. A key measure will be the actual noise dose reduction attained through increased prevention behavior and usage of dose monitoring systems.

Intermediate Goal 2.4: Improve the reliability of communication in noisy workplaces.

Both hearing impaired and normally hearing workers face special communication challenges while wearing hearing protection devices in noisy workplaces. These include localization issues, problems communicating with other workers during actual work cycles, and not hearing safety cues, such as backup alarms. Guidelines will be developed that identify new communication issues, while remaining consistent with existing standard systems, using actual noise simulations, along with the testing of different types of hearing protectors for attenuation, localization, or other characteristics that affect intelligibility.

Performance Measure: This goal will be achieved to the extent that key stakeholders acquire, accept, and implement the guidelines on alleviating communications issues by 2006.

Strategic Goal 3: Reduce repetitive/cumulative musculoskeletal injuries in mine workers

Musculoskeletal injuries, primarily to the low back, neck, knees, shoulders, and arms, are a continuing concern within the mining industry. Over 45% of all MSHA reportable incidents during 1993-2002 were classified as musculoskeletal, which is a larger percentage than that of other industries. Many barriers to preventing these injuries exist in mining, including work in awkward or restricted postures, in muddy, wet, or icy conditions, and in hot or cold environments, as well as exposure to high levels of whole-body vibration, significant amounts of heavy manual work, and an aging workforce.

Reducing the incidence of musculoskeletal injuries in mining is dependent upon improved job design and work practices. These require an enhanced understanding of the physical capabilities and limitations of mineworkers, and the development of an effective process to institute job changes that reduce musculoskeletal risk at the mine.

Performance Measure: This goal will be achieved through successful delivery of the subsequent intermediate goals, which will result in a 30% reduction of the MSD 2003 baseline injury rate by 2014.

Intermediate Goal 3.1: Quantify job demands and physical capabilities of miners to develop improved recommendations for work design.

One effective method of reducing musculoskeletal injury risk is to ensure that the demands of a job are well within the worker's capabilities. Unfortunately, data on mining job demands and miner work capacity are scarce. Studies in our Laboratory and Ergonomics Research Mine (currently under construction) will provide data on job demands and worker capacity for improving the job design at the mine site. A current emphasis is to examine the effects of aging on the physical capabilities of miners, so that jobs can be designed to accommodate the aging mining workforce.

Performance Measure: This goal will be achieved by providing 10 improved designs and work practices for reducing musculoskeletal exposure in mining jobs by 2009.

Intermediate Goal 3.2: Develop and field test ergonomic interventions to reduce worker exposure to musculoskeletal risk factors.

Research has shown that an ergonomics process which identifies ergonomic risk factors, devises solutions to reduce injury, and evaluates the effectiveness of the solutions can effectively lower worker exposure to musculoskeletal risk factors and improve worker performance. Yet, few mining companies have an ergonomics process implemented in their operations. Despite the unique challenges present in the mining environment, the logical approach to building ergonomics awareness, field testing and adoption of the laboratory proven interventions in the work place, will pave the way for a significant reduction in repetitive injury rates.

Performance Measure: This goal will be achieved by reducing the repetitive injury rate by 25% at test mine sites by 2009, using the 2003 rate as baseline.

Strategic Goal 4: Reduce traumatic injuries in the mining workplace

The primary focus of the research is to prevent traumatic injuries related to electricity, machinery, powered haulage, and falls in mining. From a severity standpoint, accidents in these classes, according to MSHA, comprise over half of the total days lost in mining from all causes. Specifically, from 1993 through 2002, there were 1,859,368 lost workdays due to traumatic injuries in these areas. Of these days lost, 50% could be attributed to falls, 25% to powered haulage, 24% to machinery, and 1% to electrical causes. Electrical injuries, though small in number, comprised 10% of deaths from these causes during the 10-year period.

Traumatic injuries could be reduced through the development and application of technologies to prevent the burns and fatalities caused by contact with electricity, and through an improved understanding of the human-machine interface and the subsequent development of technologies to protect workers in close proximity to large equipment. Reduction of injuries from slips, trips, and falls to the same level may be facilitated with enhancements to worker clothing or the integration of new wearable sensor technologies into the clothing. The small but persistent number of injuries and fatalities from blasting could be reduced through improved training and an improved understanding of the variations in explosive formulations that can contribute to unexpected results.

Performance Measure: This goal will be achieved through successful implementation of the subsequent intermediate goals, which will result in a 30% reduction in traumatic injury rates by 2014 from the 2003 baseline.

Intermediate Goal 4.1: Develop interventions for preventing electrocutions and burn injuries.

Electricity is the fourth leading cause of death reported in the mining industry by MSHA, with about 20% resulting from incidental contact with overhead power lines by high-reaching mobile equipment. Burns are the predominant nonfatal electrical injury. About half of mine electrical accidents are sustained during electrical maintenance, with meters, circuit breakers, and disconnects associated with many of the incidents. Further, lightning strikes on the surface may be communicated to underground mine workings and cause ignitions of methane-laden atmospheres. These hazards can be modeled in the Mine Electrical Laboratory, which features high-power, high-voltage, and high-current sources calibrated to NIST standards.

Performance Measure: This goal will be achieved through a 25% reduction in the 2003 baseline electrical injury rate by 2009.

Intermediate Goal 4.2: Develop interventions for preventing injuries related to machine safety and powered haulage.

MSHA data gathered from 1996 through 2000 showed that powered machinery incidents comprised almost 44% of incidents reported. During this same period, 77% of all fatalities were classified as related to powered machinery. The load-haul-dump, shuttle car, and mantrip are consistently the top three machine types cited for powered haulage-related injuries and accounted for 95% of the powered haulage incidents due to jarring and jolting. The potential for health and safety risks introduced by new technologies must be addressed proactively. Of particular importance is to understand the system requirements and specifications and to address human interface issues involving the design, operation, maintenance, computerized control, and repair of the equipment.

Performance Measure: This goal will be achieved by a 25% reduction in the 2003 baseline traumatic injury rate pertaining to machine safety and powered haulage-related injuries by 2009.

Intermediate Goal 4.3: Investigate wearable sensor technologies for empowering the miner to take proactive steps in decreasing his/her exposure to work-related injuries.

MSHA data gathered between 1998 through 2002 showed that lost-time injuries for mining operations totaled over 53,000, with a rate of 3.8 per 100 full-time employees. Underground coal's rate for the same period was more than double that number. Over 25% of the injuries were from falls (16%) and machinery (11%). Accessibility to sensory information poses problems, because workers might need to put themselves in unsafe areas or positions in order to obtain sensory information. Also, it may not be physically possible for a miner to obtain all the appropriate sensory information to manage hazards as they perform their work tasks and activities. Real-time environmental and biometric information provided through wearable sensors enables the miner to take proactive safety steps to avoid impending and/or existing hazards.

Performance Measure: This goal will be achieved by a 25% reduction in the 2003 baseline injury rate related to machinery, slips, and falls by 2009.

Intermediate Goal 4.4: Reduce the incidence of injuries and fatalities resulting from the use of explosives in the mining industry. This will be accomplished through the development and distribution of training materials consisting of toolbox training sessions and one or more videos.

Blasting is a critical component of surface mining operations and the construction industry. Billions of pounds of explosives are used annually in the United States by these industries. Each and every blast is associated with the production of toxic fumes and the projection of rocks from the blast.

Performance Measure: This goal will be achieved if the flyrock training materials are transferred to 75% of the blasting specialists for the mining industry by 2006. The transfer will be achieved if MSHA incorporates the materials as part of its annual mining health and safety training.

Intermediate Goal 4.5: Develop interventions, best practices, and strategies for improving miners' training with respect to hazard recognition, risk factor awareness, and emergency response. These interventions are critical to ensuring that workers are well prepared to assess, prevent, and/or respond to hazardous situations. Mine safety and health professionals have long recognized training as a critical element of an effective safety and health program. Federal regulations (30 CFR 46 and 48) require mine operators to provide initial and refresher training each year. The time and money being spent to train U.S. miners is substantial. There is a strong and steady demand for new and better mine training materials and methods.

Performance Measure: This goal will be achieved to the extent that our published research findings and training interventions (1) become adopted by mine safety and health trainers and (2) are referenced and advocated by mine training and safety professionals.

Strategic Goal 5: Reduce the risk of mine disasters (fires, explosions, and inundations); and minimize the risk to, and enhance the effectiveness of, emergency responders

Historically, mine disasters (five or more fatalities per incident) have been the driving force behind enactment of mining laws and regulations and government entrance into mining health and safety research. These have occurred at irregular intervals over the last 80 years, resulting in nearly 10,000 worker deaths. Recent incidents over the past few years are stark reminders that these events can occur in the U.S. mining industry at any time and have not been eradicated. An explosion at the Jim Walter Resources No. 5 Mine in Alabama in September 2001 resulted in 13 fatalities. Another two miners were killed and eight injured in July 2000, in an explosion at the Willow Creek Mine in Utah. In another incident, the rapid inflow of millions of gallons of water into the Quecreek Mine in Pennsylvania on July 24, 2002, trapped nine miners, while nine others barely escaped in a widely publicized rescue. Emergency responders, such as mine rescue teams, are relied upon to save lives during a mine disaster. Because of the nature of these emergencies and the particularly hazardous and unique aspects of the mining environment, the responders need to be well-trained and equipped and fully understand the hazards that they may face during exploration, rescue, and recovery operations. There are a number of issues facing the U.S. mining industry to reduce or eliminate disasters and to maintain the capability to adequately and safely respond to mine emergencies and potential mine disasters.

The major barriers to reducing or eliminating mine disasters and improving the safety and chances for successful rescue and response operations include the following:

1. An incomplete understanding of the root causes of mine fires, explosions, and inundations.
2. The lack of totally effective engineering controls to prevent, detect, and mitigate mine disasters.
3. The lack of education and training of the general mine workforce pertaining to methods to predict, prevent, and deal with mine emergencies.

Performance Measure: This goal will be achieved by reducing the number of injuries and deaths attributed to mine fires, explosions, inundations, and rescue and response activities between 2010 and 2014 by 25% compared to the average yearly totals from 1990 to 2001, as measured by MSHA accident statistics.

Intermediate Goal 5.1: Reduce the number of reportable (½ hour or longer) fires in U.S. mines by 25% in 5 years through the development of new or improved strategies and technologies in the areas of mine fire prevention, detection, control, and suppression.

Fire continues to be a serious hazard to the health and safety of our Nation's mining workforce. From 1990 through 2001, there were 1,060 fires, resulting in 560 injuries and 6 fatalities at U.S. mining operations. Fire in an underground mine is especially hazardous because of the confined space, problems with ventilation and mine gases, and, often, limited and long evacuation routes. Fire catastrophes such as the 1984 Wilburg Coal Mine fire in Utah, which clamed the lives of 27 miners, and the 1972 Sunshine Silver Mine fire in Idaho with 91 fatalities must continue to be prevented in the ever changing and technologically complex mining industry. PRL mine fire experts have examined the mining fire incidents and have developed a research program to address identified gaps in mine fire prevention, detection, control, and suppression, and are summarized by mining sector below.

The following gap areas were identified in the metal and nonmetal mining sector: potential use of inappropriate materials and materials whose combustibility have not been properly assessed, inadequate fire detection and suppression systems, lack of adequate fire safety standards, and a lack of knowledge of general fire safety principles.

In the coal sector, the following gap areas were identified: the preponderance of cutting and welding initiated fires, fires initiated by the spontaneous combustion (self-heating) of coal, and firefighting, containment, and response technologies. Analysis of fires in the coal mining sector showed that 20% were the result of either flame cutting or welding operations. The root causes of flame cutting and welding-related fires need to be determined and new and improved methodologies and technologies developed and evaluated to prevent these types of fires. Spontaneous combustion continues to be a problem for most Western mines, and the risk is being compounded by appreciable methane in these newer and future mines. Ventilation schemes that can mitigate these two competing hazards need to be developed. Recent fires at coal mines have demonstrated an inadequate development and understanding of the technologies for remote application of extinguishing agents (foam, water, inert gas, etc.), deployment strategies for firefighting equipment (inert gas engines, foam generators, etc.), permanent and temporary fire containment sealing technology, and emergency ventilation control measures. Research must evaluate these devices and technologies under full-scale mine conditions to develop reliable deployment strategies that will help to ensure a safe and successful outcome during a mine fire. The dynamics of a coal mine fire initiation, growth and spread, smoke movement, and contaminant interaction with the ventilation are complex phenomena that are not well understood. Further research into these aspects can lead to an interactive mine fire simulator, which could then be more efficiently applied to emergency smoke management and fire suppression decisions, increasing miner safety.

Performance Measure: This goal will be achieved by reducing the number of fires in the coal and metal/nonmetal mining sectors between 2010 and 2014 by 25% compared to the average yearly totals from 1990 to 2001, as measured by MSHA mine fire statistics.

Intermediate Goal 5.2: Develop and facilitate the implementation of interventions to address currently identified shortcomings in the coal mining explosion prevention "safety net."

The recent reappearance of deadly coal mine explosions in the U.S. is alarming. Bracketed around the September 2001 sentinel event of the explosion at Jim Walter Resources (JWR) No. 5 Mine in Alabama (13 fatalities and 3 injuries) were the July 2000 explosion in at the Willow Creek Mine in Utah (2 fatalities and 8 injuries) and the McElroy Coal Mine explosion in West Virginia (3 fatalities and 3 injuries) in January 2003. These events signal that coal mine explosion incidents still take an unacceptable human toll and clearly demonstrate that some of the problems that can result in mine explosions have yet to be solved. Equally disconcerting is that certain changes affecting the underground coal industry indicate that the risk of mine explosions may increase in the near future. Among these events/changes are (1) an ongoing high level of frictional ignition incidents (62 per year over the last 5 years); (2) the impending exodus of large numbers of highly experienced miners, mining professionals, and mining enforcement personnel; (3) the depletion of "easy-to-mine" coal reserves and movement into "difficult," deeper reserves with increased amounts of methane; (4) technological and operational changes, such as higher mining productivity rates and longer and wider longwall panels that compound methane issues; and (5) the persistence of various potential ignition sources.

The recent mine explosions were studied extensively by labor, industry, and government experts. As a result, the following gaps in the explosion "safety net" were identified: (1) the lack of a full understanding of the critical parameters and their interrelationships governing the potential propagation of an ignition to a large mine explosion; (2) the lack of understanding of the mechanics and controlling parameters of explosions involving large volumes of nonuniformly mixed methane; (3) the lack of a full suite of explosion forensic investigation tools and information; (4) the need for a more complete understanding of the interaction of coal dust with the rock dust applied in mines as an explosion suppressant to insure adequately suppressed explosions; (5) the need for a more complete understanding of the process that leads to frictional ignitions; a need for a rapid, on-the-spot means to assess the explosion potential of specific mine areas; (6) the need for a means to assess that in-place mine seals are adequate to perform their function; and (7) the lack of, or inadequate, explosion training and educational materials for the upcoming rapid influx of inexperienced miners, mine professionals, and regulators. These identified areas serve as the basis to develop research plans to address the shortcomings and form the basis for a systematic approach to explosion prevention.

Performance Measure: This goal will be achieved by reducing the number of injuries and deaths attributed to mine explosions between 2010 and 2014 by 25% compared to the average yearly totals from 1990 to 2001, as measured by MSHA accident statistics.

Intermediate Goal 5.3: Reduce or eliminate inundations in U.S. coal mines within 7 years through the development of bulkhead (structures to impound water in mines) design guidelines to be published by 2009. Also, to help reduce the safety hazard to miners from inundations, publish mine design guidelines that would mitigate or prevent inundations by 2009.

Underground mines routinely install solid structures called seals and bulkheads across mine openings for a variety of purposes. Seals are used to isolate abandoned coal mine workings that may contain a potentially explosive atmosphere from active areas of a mine. A bulkhead is used as a dam to contain water or liquidlike mine wastes (tailings or slurry) in abandoned mine workings. Bulkheads must withstand the expected hydraulic pressures exerted by water or slurry in the impoundment area behind the bulkhead. Failures of the bulkheads can result in rapid inundation of water, threatening miners' lives. Past bulkhead failures and a number of issues related to the use and design of these structures noted by experts in this area indicate the need for more robust guidelines regarding their use, deployment, and design to remove this hazard in the future.

Several gaps exist in the current knowledge base of the causes of mine inundations. These include the failure mechanisms of bulkheads constructed specifically to impound water and the inadvertent and sometimes undetected accumulation of water behind ventilation seals that fail because they are subjected to hydraulic pressures for which they were not designed. Currently, no specific engineering design criteria, construction guidelines, postconstruction inspection, or monitoring practices exist for bulkheads, nor does MSHA require that new bulkhead designs be subjected to a full-scale performance validation test. Developing sound engineering-based design criteria, construction guidelines, post construction inspection, and monitoring practices for bulkheads can significantly reduce the disaster potential associated with their failure. In addition, no mine design criteria exists to prevent or mitigate the occurrence of mine inundations in general and to increase the potential for the workers to escape.

Performance Measure: This goal will be achieved if (1) improved mine designs and comprehensive bulkhead design, inspection, and monitoring guidelines are developed and adopted by the industry (MSHA) within 5 years and (2) the number of mine inundations related to bulkhead failures are reduced by 50% within 7 years (baseline is 20 year period between 1983 and 2002). MSHA is a cooperator in this research.

Intermediate Goal 5.4: Assist the mining community to maintain and improve mine escape, rescue, and emergency response capabilities through realistic training exercises and the development and implementation of new or improved training aids and exploration, rescue, and escape technologies.

Approximately 780 underground coal mines and 240 underground metal and nonmetal mines operate in the United States, employing a workforce of 59,300. Currently, there are only 120 coal mine rescue teams and 116 metal and nonmetal mine rescue teams that can respond to an emergency at these mines. Because of the unique nature of these emergencies, rescue team members need to be well trained, physically fit, and equipped with the latest technology, and they must fully understand the hazards that will be encountered during exploration, rescue, and recovery operations. Mining is considered to be one of the most hazardous occupations, and it may be argued that mine rescue and response may be the most hazardous occupation in mining. Research is needed to develop improved tools for mine rescue and response in the mining industry. Hurdles that prohibit the use of aboveground technology in underground mines, such as permissibility issues, must be overcome. Because of the small market for this technology, partnerships with industry to bring this technology to the marketplace must be strengthened. The decrease in the number of mine rescue teams and team members is reaching a critical mass. Combined with the aging miner workforce and the economics of the coal industry, the numbers of mine rescue teams are not likely to increase and there will be an influx of highly inexperienced personnel on the existing teams. Innovative methods to recruit and train new members need to be developed and implemented.

Performance Measure: This goal will be achieved over the next 5 years through (1) the participation of 75 mine rescue teams and 2,500 miners in NIOSH-led training to improve their safety, skills, effectiveness, confidence, and teamwork for rescue and emergency operations; and (2) the incorporation of improved NIOSH-developed strategies and technologies for mine rescue and response into practice and deployment activities by at least 25% of U.S. mine rescue teams.

Strategic Goal 6: Reduce ground failure fatalities and injuries in the mining industry

Mining has the highest fatal injury rate of any U.S. industry, at more than five times the national average, and ground failures have historically accounted for up to 50% of the fatalities in underground mines. Nonfatal injuries from ground failures tend to be severe, resulting in a high percentage of lost time accidents for the mining industry. Even roof falls that do not cause an injury are significant hazards in underground mines. More than 1,400 noninjury, major, unplanned roof collapses were reported to MSHA in 2004. These roof collapses threaten miners, damage equipment, disrupt ventilation, and block critical emergency escape routes. Roof collapses also helped trigger recent mine disasters in Alabama and Utah, which together claimed 15 lives.

The structural integrity of the underground mine complex is essential to the mining operation and ensuring the ground stability of the mine complex is a significant undertaking and a specific operation for all mines. Fifteen to twenty percent of the operating costs of an underground mine complex are associated strictly with operations directly tied to preventing ground failures.

Barriers to preventing ground failure fatalities and injuries in underground mines include the need to develop models that incorporate an understanding of rock mass behavior given specific geological and geotechnical conditions (high stresses, interactions with surrounding mines), the development of technologies and strategies to prevent rock falls once the failure is understood and characterized, full-scale and accurate testing and structural characterization of newly developed support systems, and the lack of a monitoring system for identifying rock mass weakening prior to failure.

Rock bursts, coal bumps, massive pillar failures, and inundations have been identified as ground control problems that can have catastrophic consequences, often resulting in severe injuries or death, and potentially affecting an entire underground workforce. They are often characterized by large, violent rock collapses that occur without warning. Because of geologic and rock strength variability, these events continue to occur in areas that have seemingly acceptable safety factors.

The barrier to developing realistic ground failure models is actual measurements of rock mass characteristics under actual mining conditions and the formulation of specific relationships which cover the range of rock behaviors from stable to unstable conditions. Unplanned roof falls occur despite technology and specific engineering design criteria that are accurately followed. These unplanned falls can be eliminated, or at the very least have a minimal impact on the miners, if they can be characterized by the use of accurate models. Technologies and strategies for preventing unplanned roof falls under specific conditions, including high horizontal stress, weak roof rocks, skin-type rock falls, and multiple-seam mining interactions, need to be developed and experimentally tested in operating mines. The technologies would bridge the gap between the understanding of the failure mechanisms and the implementation of systems for preventing the failures.

The barrier to eliminating the injuries associated with support systems requires the full-scale performance testing of the systems under actual mining conditions. Standing roof support systems that maintain the opening between the mine roof and floor are routinely installed in all mines in an effort to prevent catastrophic roof falls from occurring, and the performance of these supports is critical to mine workers' safety. A database of support performance characteristics must be maintained and available to the entire mining community to ensure proper application of this support technology. The only laboratory for conducting the experimental full-scale tests is the Mine Roof Simulator.

The third barrier is the availability of technology to forecast or warn of impending roof falls. If an area appears to be unstable, current practice allows for the deployment of point-source monitors to evaluate the rate of entry convergence in the areas of concern. Typically, this approach is haphazard at best and has shown extremely limited success in identifying rock failures. There is currently no technology for monitoring an overall mine complex which provides accurate and timely information on the state of stability for the roof, floor, or surrounding rock layers. Recent research findings by NIOSH have identified an approach using multiple sensors (microseismic and deformations) that appears to have promise for solving the problems of rock failure forecasting. The principle barriers to deploying this technology lie in our lack of understanding of the microseismic precursor patterns associated with roof falls and the impact of local geologic and mining conditions on these same precursor patterns. There are also issues with enhancing the analysis and display of microseismic and convergence data in real-time.

Performance Measure: This goal will be achieved if (1) mine fatalities by ground failures are reduced by 50% within 8 years, (2) injuries by ground and roof support system failures are reduced by 25% within 5 years and by 50% within 8 years, and (3) unplanned roof falls are reduced by 20% within 5 years and by 40% within 8 years.

Intermediate Goal 6.1: Reduce the number of ground failures in underground mines by improved understanding of rock mass failure mechanics using in-mine experiments and numerical analysis models. Develop better methods for characterizing rock strength properties using novel techniques such as downhole electric logs and in-mine drilling analysis. This information will provide reliable input data that, when combined with a knowledge base of failure mechanisms for major failures observed in underground coal and metal/nonmetal mines, will allow the construction of accurate computer models. Using these models and the knowledge gained, develop strategies and interventions to eliminate the failures or reduce the hazard associated with the failures.

Performance Measure: This goal will be achieved if models are developed and successfully applied to explain the coal mine entry and coal mine caving/overburden response (3-year timeframe) and the failure modes caused by horizontal stresses in stone mines (4-year timeframe). The goal will also be achieved if the developed models and related knowledge, complete with appropriate design and intervention approaches, are transferred to the industry within 6 years.

Intermediate Goal 6.2: Reduce rock fall injuries in coal mines through enhanced application of roof surface control technology.

Each year more than 500 coal miners are injured and one or more are killed by relatively minor falls of rock in coal mines. These injuries are quite severe, resulting in an average of 50 lost workdays for each occurrence.

NIOSH is using a multipronged approach to reduce the number of rock fall injuries. Research is being done to determine the most effective of roof surface control technologies for different geologic environments. "Best practices" for installing surface controls using different types of roof bolting machines are also being documented. As gaps in the technology are identified, new roof surface control technologies are being developed. One example is the personal bolter screen that is currently being tested for use in thin seams and hard-to-reach roofs.

Performance Measure: This goal will be achieved by reducing the number of rock fall injuries in coal mines by 50% over the next 5 years.

Intermediate Goal 6.3: Reduce the ground control failures resulting from multiple-seam interactions through the development of design-based control technology.

More then 70% of the Nation's coal mines are located in areas where past mining has already been conducted, creating the possibility of multiple-seam interactions. Many of these mines are currently encountering ground stability problems because of concentrated ground stresses or fractured rock due to interactions from nearby mines. These interactions severely impact the stability of the mine structure, resulting in dramatic increases in roof, pillar, and floor failures. In extreme cases, dramatic collapses, possibly associated with inrushes of water, can occur. Multiple-seam instabilities have contributed to several fatalities in recent years.

NIOSH is now developing multiple-seam design guidelines that will help mine planners minimize the risk associated with multiple-seam interactions. The guidelines will integrate statistical back analysis of documented case histories with sophisticated numerical models.

Performance Measure: This goal will be achieved by (1) providing multiple-seam design guidelines to the mining industry within 3 years and (2) reducing instances of severe multiple-seam interactions by 80% within 8 years.

Intermediate Goal 6.4: Reduce the number of unplanned roof falls by developing new ground control technology for mines with low strength roofs. Develop improved mine layouts for stress control and prevention of time-dependent failure, and guidelines for effective roof support.

Coal miners working beneath a low-strength roof face significantly greater hazards from rock falls than most underground miners. MSHA statistics show that just 30 mines, accounting for about 5% of underground production, were responsible for nearly 25% of all unplanned roof falls during 1995-2002. These mines are located almost exclusively in the Illinois and northern Appalachian coal basins. Available ground control safety technologies developed for the broad range of U.S. mining conditions tend to be less useful when applied to mines with an extremely weak roof.

A low-strength roof is vulnerable to even low levels of horizontal stress. Fundamental studies are needed to explore the relationship between stress level and rock stiffness, and the relationship between depth and horizontal ground stress. Control technologies include improved mine layouts and better guidelines for rock strength characterization and support selection.

Performance Measure: This goal will be achieved when the newly developed ground control technologies are adopted by the target mine population. This is expected to result in a 50% reduction in the number of roof falls at these mines. The technologies will also be applicable to the estimated 25% of U.S. coal mines that occasionally encounter weak roof conditions.

Intermediate Goal 6.5: Development of more effective support-based ground control technology and decision logic for selecting the best support systems for specific geologic environments. Eliminate the trial-and-error application of these critical support systems.

Ground control is a fundamental aspect of all underground mining. Historically, between 30%-40% of the fatalities in underground mines are caused by inadequately supported roof rocks falling and striking the miner. Most unplanned roof falls can be attributed to incorrect application of support. Despite years of research, however, there are still many fundamental questions about issues like the role of tension in roof bolting and the interaction between primary and supplemental supports. Better guidelines for support design, based on improved ground control science, could be employed by mine planners and mine safety officials to significantly reduce the number of roof collapses.

New types of standing supports are being developed that offer improved ground control as well as better ergonomic and other advantages. Before they can be widely used with confidence, however, their characteristics must be thoroughly evaluated.

Performance Measure: This goal will be achieved if (1) 15 new standing supports are characterized over the next 5 years and if more efficient standing support systems are developed and successfully implemented in the mining industry, and (2) new decision logic for support selection and implementation is adopted by large segments of the mining industry.

Intermediate Goal 6.6: Develop a sensor-based risk-management system for roof falls in stone mines.

The fatality rate for underground nonmetal miners is 20 times higher than the average for all industrial sectors. Roof falls are responsible for a significant portion of the fatalities and injuries in underground nonmetal mines. Roof falls in these mines are rarely anticipated because significant mining heights (20-60 ft) make it difficult to recognize deteriorating conditions that might warn of impending roof failures. During 1983-2002, 936 unplanned roof falls occurred in U.S. underground nonmetal mines. About 77% of these roof falls injured miners, resulting in 15,974 lost workdays. The development of sensor-based roof fall warning technology will allow for early detection of the deteriorating conditions, removal of mineworkers, stabilization of the roof rock, and, ultimately, changes in mine plans, so that exposure of workers to these hazards can be eliminated.

The goal is to develop sensor-based technology and the accompanying fundamental knowledge that will allow us to provide some warning of roof falls over large areas of a mine. It is also important to establish where such warning technology is feasible. Currently, miners have little, if any, warning of roof falls.

Performance Measure: This goal will be achieved if a sensor-based risk-management system for roof falls is developed and used in 20% of underground stone mines within 4 years.

Intermediate Goal 6.7: Reduce rock bursts caused by high stress buildup by developing methods to asses the level of danger associated with potential rock bursts, eliminating the occurrence of rock bursts by safely reducing high rock stresses, and reducing the injuries caused by rock bursts by improving rock destressing techniques and hazard assessment technology.

Rock bursts and bumps are a small percentage of the total ground fall incidents, but because they occur in relatively few mines, they pose a higher risk to workers at those locations than industry-wide averages would suggest. For example, the rate of rock burst fatalities in the Coeur d'Alene Mining District in Idaho is eight times greater than the industry average for all causes of death.

Performance Measure: This goal will be achieved when the ground control technologies developed are adopted by 50% of the target mine population.

Strategic Goal 7: Determine the impact of changing mining conditions, new and emerging technologies, and the changing patterns of work on worker health and safety

The geologic conditions under which mining is conducted are generally becoming worse, exposing workers to increasing risks. Changing patterns of work, including workforce demographics and shift schedules, may adversely affect the safety and health of the workforce. Emerging technology may improve worker health and safety, or it may result in new hazards that compromise existing health or safety. Interventions developed by NIOSH may help mitigate health and safety hazards, but their effectiveness and extent of actual use will need to be determined.

It has been over 2 decades since the last demographics study of mine workers was performed. A new survey is needed to understand changes in the workforce and to provide accurate "denominator" data for surveillance analyses. The organization of work in the mining industry is undergoing significant changes globally, and some of these are occurring in the United States. The effect of these on worker safety and health is largely unknown, but the limited data available suggests that these changes may not all be positive. The effects need to be understood before consideration can be given to any interventions. As the mining industry has consolidated, the rate at which relevant new technologies are emerging has slowed. Nonetheless, the technologies must be studied in order to understand their potential impact on worker safety or health. Finally, changes in the industry are occurring, in part, from the introduction of NIOSH-developed interventions. The effectiveness of these interventions should be studied more formally, both to guide the research program and to promote widespread adoption of the most successful interventions.

Performance Measure: This goal will be achieved if the impacts of the changes have been identified and recommendations for mitigating adverse impacts are issued over the next 10 years. It should be noted that the intermediate goals identified here are, in most cases, looking at emerging or other issues in which the actual threat to mineworker safety and health is unclear. Accordingly, the performance measures are less quantitative than those of other strategic goals.

Intermediate Goal 7.1: Conduct a demographics survey of mine workers. Such a survey will be invaluable, not only for denominator data, but for guiding research and training activities that are necessary to prevent a sharp increase in occupational health and safety problems in the evolving workforce.

Performance Measure: This goal will be achieved by completing and publishing a comprehensive demographics survey of the mining industry by 2009.

Intermediate Goal 7.2: Document organization of work changes in the domestic and global mining industry and assess their impact on worker health and safety. Work organization refers to the way work processes are structured and managed, and it deals with subjects such as the scheduling of work, job design, interpersonal aspects of work, management style, and organizational characteristics, such as climate, culture, and communications. Work organization is influenced by factors such as economic conditions, technologic change, demographic trends (e.g., the rapid aging of the mining workforce), and changing corporate and employment practices. These trends may adversely affect work organization and may result, for example, in increased work load demands, and longer and more varied work shifts. However, the actual effects of these trends on the conditions of work and on the well-being of miners have received little study.

Performance Measure: This goal will be achieved if the impacts of organization of work changes have been identified and recommendations for mitigating adverse impacts are issued over the next 5 years.

Intermediate Goal 7.3: Examine emerging technologies for potential health and safety benefits/risks.

NIOSH sponsored two major recent studies of emerging technologies, which could have significant impact on health and safety of miners. These were published by RAND Corp. in 2001 and by the National Research Council in 2002. The identified emerging technologies will be monitored, and efforts will continue to track new developments and their impact on mining safety and health. This is a low-level effort given the relatively slow infusion of new technologies in mining, and will not require a separate project effort in the foreseeable future.

Intermediate Goal 7.4: Develop a more rigorous program to assess the effectiveness of NIOSH-developed interventions.

The effectiveness of certain safety interventions can be assessed over a relatively short period of years, whereas the effectiveness of many health interventions cannot be fully assessed in less than a worker's lifetime. Moreover, the tendency is to investigate new solutions, rather than do an assessment of past ones. This is no longer an acceptable practice; the impact of research and prevention expenditures must be better understood.

Tools must be developed or adapted to facilitate quantitative assessments of the economic impact of interventions, and models are needed to examine the efficacy of intervention alternatives in a mix of possible health and safety interventions. These tools and models should provide a modest forecasting capability, given the latency of many interventions.

Performance Measure: This goal will be achieved by (1) establishing intervention effectiveness measures for all program areas within 2 years; (2) undertaking intervention effectiveness studies within 3 years and publishing the effectiveness of interventions within 1 year of completion of each study; (3) studying mathematical tools that analyze the economic impact of interventions and, within 2 years, selecting and integrating one or more tools into the appropriate research projects; and (4) developing and evaluating a model for the aggregates industry within 4 years, distributing it publicly within 5 years, and if successful, undertaking similar efforts for other sectors of the mining industry.

Intermediate Goal 7.5: Reduce fatalities and injuries resulting from physiological stresses caused by extreme environmental combinations of climatic, geothermal, and ambient conditions in western metal and nonmetal mines.

U.S. mine workers face a work environment possessing health stressors that is unique among occupations. In addition to the whole-body vibration, chemical, particulate, noise, and gas exposures, miners endure environmental extremes, rotating and extended shifts, low light levels in underground mines, and physically demanding tasks. Many of these stressors are the subject of directed research programs in NIOSH. The combined effect of these and other stressors result in exposures which can cause acute health effects and accidents because of impaired judgment and reduced reaction times. A review of accident and illness data, as well as literature on the subject, has identified fatigue, heat strain, and cardiovascular disease-related death as problem areas where directed research has the greatest potential to reduce fatalities, illness, and injury. As such, this is an area that is being closely studied to determine an appropriate research response.

Cases of heat illness reported to MSHA are relatively rare, averaging 28 per year during 1999-2004. However, they have resulted in three deaths in the past 5 years. In order to be considered reportable to MSHA under 30 CFR 50, an incident must require medical treatment other than observation or preventative measures, have resulted in a loss of consciousness, or cause the employee to be unable to perform his/her normal job duties on subsequent days. Because of these reporting criteria, it is likely that only cases of severe hyperthermia are captured by the MSHA surveillance system. Half of all reported cases of heat illness result in lost or restricted duty, averaging 5 days per incident.

Performance Measure: This goal will be achieved through (1) development of appropriate recommendations for the mining industry to alleviate the health risks associated with physiological stress caused by extreme environmental conditions within 3 years and (2) adoption of the recommendations by 25% of the affected mines within 5 years.

Intermediate Goal 7.6: Reduce injuries and illnesses caused by chemical hazards found in mining by conducting epidemiological studies that track disease and illness.

Chemicals are essential for life processes. However, we know from other industries that toxic doses may lead to lung disease, cancer, burns, poisonings, sterility, heart and kidney disease, dermatitis, and numerous other health problems. Chemicals used in mines or produced from the mining process include fuels, lubricants, solvents, cyanide, silica, metals, and many others. Often such substances have a direct link to occupational diseases. Concerns have been raised about chemicals used in mineral processing such as acrylamide, manganese, arsenic and cyanide, as well as those used or present in mining operations, such as nickel, lead, cadmium, platinum, and mercury. The development of a database regarding the chemicals and disease and illnesses will be useful for health and safety researchers and will also further improve surveillance studies of the mining community.

MSHA recently enacted a Hazard Communication Standard in an effort to raise awareness of the hazardous chemicals in the workplace. MSHA has also acknowledged that "miners suffer numerous long-term health problems from chemicals as well. These illnesses, however, may occur years after an exposure when the relationship of illness to chemical can be difficult to see." There are important research and prevention activities based on our current knowledge, and there is an important need to assess the possible impact of chemicals that mineworkers are exposed to, in the course of their work. The former is addressed elsewhere in this Plan; the latter is the focus of this intermediate goal.

Performance Measure: This goal will be achieved if a disease and illness database for the mining industry is developed by 2008.